BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: AGC Reprogramming Study--Utility and Service Programs - Case 320

DATE: March 29, 1968

FROM: J. J. Rocchio

ABSTRACT

A brief analysis of the utility and service portion of the Apollo Command Module and Lunar Module guidance computer programs was conducted in support of Bellcomm's study of the feasibility of achieving a substantial reduction in the size and complexity of the AGC software. The current allocation for utility and service programs in both the CM and LM computers is on the order of 12,700 words. The first cut analysis indicates a potential saving of 5000 words from this total.

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MEMORANDUM FOR FILE

1. INTRODUCTION

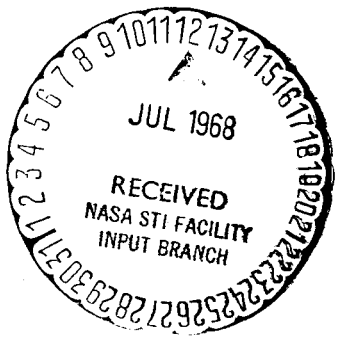
As part of Bellcomm's study of the feasibility of reducing the size and complexity of the programs for the Apollo command module and lunar module guidance computers, a brief investigation of the utility and service routines was made. Since these programs are either identical or very closely related in both computers (except for the routines associated with the LM radars, which have no counterpart in the CMC) they can be discussed without differentiating between the CM and LM.

The baseline for the study was an MIT/IL document providing budgeted and actual memory word allocations for CM program Colossus Rev. 135. These are shown in Table 1, along with the estimated allocations for the proposed reduced program, for all routines categorized under the heading Utility and Service Programs. Individual routines in this category allocated less than 100 words of memory are lumped under a miscellaneous heading. As the requirements on the utility and service programs are essentially mission independent, it was assumed that these allocations were representative of the lunar landing mission programs.

2. BASIC ASSUMPTIONS

The objective of the programming study was to examine the feasibility of reducing the requirements on the guidance computer program by simplifying computer operations and sacrificing nonessential accuracy or minor savings in required propellants. Analysis of the tradeoffs associated with the required guidance computer functions by the study group led to the following assumptions pertinent to potential reductions in the size of the utility and service routines:

a. Extensive use of single precision arithmetic operations, in place of currently used double precision, was feasible.



b. Computer operations in response to a hardware-generated restart would be greatly simplified, and the requirements for "restart proofing" of programs would be eliminated.

c. The number of nouns defined for DSKY use would be reduced and the requirements on input and display scaling would be relaxed.

d. A time-multiplexed executive system was feasible and would result in a strict time cadence of programs in each mission phase. This would replace the current job list, priority-based executive.

3. PROGRAM SIZE ESTIMATES

Each of the major programs grouped under the category of Utility and Service Routines was analyzed from a functional viewpoint. In some instances, as for example, with the restart programs, the assumptions outlined above allowed a complete elimination of a function, and the corresponding size estimate could be reduced to zero. In the other cases the proposed size reductions were based either on the elimination of some set of subfunctions performed by a given routine or a general reduction in the overall requirements of the mission programs.

3.1 Major Reductions

3.1.2 Pinball and Display Interface

The Pinball program incorporates the logic, control, and data manipulation capabilities required for the exchange of information between the astronaut and the guidance computer. A major contribution to the size of this program is the number of nouns defined for a given mission. Each defined noun requires entries in one or more tables. In addition, many nouns require special scaling routines for input and display. The 30% reduction in the Pinball allocation is based primarily on reducing the number of nouns and the associated scaling routines.

In addition, the set of programs under the label Display Interface are related to DSKY operations. These routines provide for various interlocks that prevent overlapping usage of the DSKY by conflicting mission programs. The almost complete elimination of this allocation was based on the proposed change in executive structure.

3.1.3 Interpreter

The AGC interpreter was also analyzed in some detail. The basis for the almost 50% reduction in memory allocation was primarily a result of the assumption of increased use of single precision arithmetic operations. On the basis of the time available for this study it was not possible to determine in fact whether an interpreter was required. However, even if there was no longer a need for it, these 1200 words allocated were felt to be a reasonable estimate of the size of those subroutines (such as the trigonometric functions) which would still be required.

4. CONCLUSION

The total reduction in the memory allocation budget for utility and service programs amounts to about 5000 words, as shown in Table 1. It must be emphasized that estimates of program requirements are notoriously difficult. Furthermore, the time available for this study allowed only a first cut at analyzing the change in requirements for utility and service routines that would result from the simplifications in G&N mission operations and in the associated computer programs. Thus, the estimate that the Utility and Service Functions in a reprogrammed AGC would require about 7700 words must be interpreted with caution.

1031-JJR-sel

J. J. Rocchio

UTILITY AND SERVICE ROUTINES

Program	Budget (Colossus Rev.135)	Actual	Proposed
Pinball and Noun Tables	3000	2875	2000
Interpreter + Subroutines	2262	2198	1200
T4 Rupt	875	789	800
Display Interface	700	678	100
Systems Test	650	633	___
IMU Mode Switching	580	573	580
Extended Verbs	550	526	500
Down Link + Lists	500	371	350
Fresh Start & Restart	420	396	270
Restart Routines & Tables	400	374	___
Extent Mark	353	358	250
Executive	328	332	500
Self Check	310	314	310
Program Select	300	268	___
IMU Compensation	250	246	100
Wait List	240	240	240
RTB Op. Codes	200	147	100
Phase Table Maintenance	183	183	___
Miscellaneous	578	586	360
TOTALS	12,679	12,087	7660
SAVINGS	5019	4327	

TABLE I

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Subject: AGC Reprogramming Study--Utility and Service Programs - Case 320

From: J. J. Rocchio

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